Makarovski District of the southern Urals." Bull. Soc. Nat. Moscou **49**: sec. geol. 18: 113–135. 1940.

TERQUEM, O. *Recherches sur les foraminifères du Lias.* Mém. Acad. Imp. Metz 1862.

THOMAS, A. O. *Late Devonian Foraminifera from Iowa.* Journ. Pal. **3**: 40–41, 1931.

THOMPSON, M. L. *The fusulinid genus* Staffella *in America.* Journ. Pal. **9**: 111–120. 1935.

———. *New genera of Pennsylvanian fusulinids.* Amer. Journ. Sci. **240**: 403–420. 1942.

WOOD, A. *The structure of the wall of the test in the Foraminifera; its value in classification.* Quart. Journ. Geol. Soc. London **104**: 229–255. 1948.

ZELLER, E. *Stratigraphic significance of Mississippian endothyranoid Foraminifera.* Univ. Kansas Pal. Publ. art. 4, Protozoa, 1950.

PALEONTOLOGY.—*Foraminifera from some "Pliocene" rocks of Egypt.* RUSHDI SAID, Cairo University, Egypt. (Communicated by Alfred R. Loeblich, Jr.)

This paper lists some 40 species of Foraminifera separated from marly limestones of a supposedly "Pliocene" outcrop in Helwan, Egypt.

The "Pliocene" deposits in Egypt have been the subject of many discussions and the basis of an enormous amount of literature. The best description of them is found in Blanckenhorn (1903 and 1921) and in Picard (1943). The most authentic and complete résumé on the Pliocene of the Nile Valley, with which this paper is concerned, is found in Sandford and Arkell (1939).

The "Pliocene" deposits of the Nile Valley occur in the form of isolated outcrops that extend along the sides of the valley in a thin strip stretching from Cairo to the vicinity of Aswan. The outcrops occupy a more or less uniform height above sea level—indicating that a narrow arm of the Mediterranean Sea occupied the Nile Valley, and on the basis of stratigraphic relations and marine macrofossils during Astian time. There are two main facies, a marine facies of limestones and marly limestones along the immediate sides of the valley in the north and a conglomeritic sandy facies in the south and in the outer fringes of this ancient "Pliocene" gulf.

The outcrop from which the following species of Foraminifera come lies some 10 km south of Helwan, a village to the south of Cairo. Macrofossils found in the outcrop include some considered to be the most typical guide fossils for the Egyptian Pliocene, such as *Ostrea cucullata*, *Pecten benedictus*, and *Chlamys scabrellus*. The section consists of beds of marly limestones and limestones some 25 meters thick unconformably overlying Eocene rocks and overlain by a gravelly terrace ascribed by Sandford and Arkell to the Plio-Pleistocene.

This study shows many interesting conclusions with regard to the age of this formation and the origin of its fauna.

Age.—The Foraminifera recorded in the area are decidedly Mediterranean in aspect. They compare well with the Pliocene and Pleistocene faunas of the Mediterranean region and many species are still living today in the Mediterranean. Four species *Cibicides gibbosa*, *C. rhodiensis*, *Asterigerina rhodiensis*, and *Quinqueloculina foliacea* are known from the lower Pleistocene deposits of the Isle of Rhodes. Practically all other species are known and are typical of other such classical late Cenozoic localities of Italy and Spain. *Unicosiphonia cf. U crenulata* is a characteristic fossil of the Pleistocene which is here recorded for the first time in the Mediterranean region.

There are some interesting points about the assemblage. The majority of the species are cold-water forms. In fact this assemblage, mainly composed of representatives of the families Textulariidae and Buliminidae, can well be compared with that living today in the deeper waters of the Recent Mediterranean (see for example the ecological studies of Colom (1942) and Said and Kamel (in press) on the Recent Mediterranean fauna). The presence of this deep-water fauna in the ancient shallow Nile Valley gulf can be interpreted only as indicating a cold climate in Egypt at the time of the deposition of this formation. The distribution of the detrital sandy facies in the gulf shows that the climate was also wet.

This type of cool wet climate compares well with the climate of the Calabrian

stage, now regarded on the basis of this kind of climate as belonging to the lower Pleistocene (Migliorini, 1948, and Movius, 1949).

This assemblage from Helwan includes many species that do not appear in the Pliocene-Pleistocene succession of the Rovigo boring, Italy (di Napoli-Alliata, 1946), except in the Calabrian. These species that seem to indicate the onset of the Calabrian stage are: *Textularia abbreviata*, *T. aciculata*, *T. sagittula*, and *Discorbis orbicularia*.

From these two interesting observations it would seem that the "Pliocene" outcrop of Helwan should be assigned to the Calabrian stage that opens the Pleistocene period. Such an assignment would have far reaching implications inasmuch as it would put the entire evolutionary history of the River Nile in the post lower Pleistocene time. A reevaluation and re-dating of the terraces left behind the Nile in pre-human times should therefore be investigated in the light of this new evidence.

Although this study has been restricted to the Helwan area, it is possible that all other outcrops of the Nile Valley described as Pliocene may also belong to the Calabrian stage since all can well be correlated on the basis of their fossil content and stratigraphical relations with those of Helwan. If such is the case the very presence of Pliocene marine deposits in Egypt is questionable. Work on the revision of the macrofauna of the so-called Pliocene of Egypt is now in progress.

Origin of the fauna.—There can be no doubt that the foraminiferal fauna described here is Mediterranean in aspect. However two facts remain to be noted. The complete absence of Indo-Pacific species in the assemblage is interesting inasmuch as it confirms the conclusions reached by Cox (1929), Picard (1943) and Sandford and Arkell (1939) as to the absence of any connection between the Mediterranean and the Red Sea since Miocene times. On the other hand, Said and Yallouze (in press) have shown recently from an analysis of the Miocene faunas of Gebel Oweibid, Egypt, that even though the fauna is overwhelmingly Mediterranean in aspect it also includes some elements of the Indo-Pacific region—a fact which points to a temporary ingression of the Indo-Pacific. The composition of the Helwan Calabrian foraminiferal fauna seems to show that this connection ceased entirely during the Pliocene and lower Pleistocene time—contrary to Ball's paleogeographic map (1939), which shows a connection between the Mediterranean and the Red Sea during the Pliocene.

The second fact to be noted is the presence of *Cibicides gibbosa* and *C. rhodiensis*, typical lower Pleistocene Mediterranean species in the Recent waters of the Red Sea. This can be explained only by assuming a temporary connection between the Mediterranean and the Red Sea in post lower Pleistocene time to allow for the migration of these species. Such a connection must have been very temporary, since it did not substantially affect the aspect of the faunas of both seas which remain distinct. This assumed connection is confirmed by the presence of a marine level in the clysmic area common to both the Mediterranean and the Red Sea (as described by Hume and Little, 1928) and dated as Midde Paleolithic.

Family TEXTULARIIDAE

Genus **Textularia** Defrance, 1824

Textularia abbreviata d'Orbigny

Textularia abbreviata d'Orbigny, Foram. Foss. Vienne: 249, pl. 15, figs. 9–12. 1849.

This distinct species occurs in small numbers in the samples from Helwan. This species has been noted from the Miocene of central Europe, but does not seem to appear in the Mediterranean until the Calabrian. It is also recorded from the Recent seas.

Textularia cf. **T. aciculata** d'Orbigny

Textularia aciculata d'Orbigny, Ann. Sci. Nat. **7**: pl. 11, figs. 1–4. 1826.

A few specimens that seem to belong to this species occur in the Helwan material. Specimens are slightly longer and thinner particularly at their initial end than in the typical form. This species appears in the Mediterranean deposits only since the Calabrian.

Textularia candeiana d'Orbigny

Textularia candeiana d'Orbigny, in de la Sagra, Hist. Phys. Pol. Nat. Cuba, "Foraminifères": 143, p. 1, figs. 25–27. 1839.

The distribution of this species in the Recent waters is cosmopolitan. In the modern Mediterranean it lives in the deeper waters, together with other representatives of the family Textulariidae.

Textularia neorugosa Thalmann

Textularia neorugosa Thalmann, Contr. Cushman Found. Foram. Res. **1**: 45. 950.

This cosmopolitan species occurs abundantly in the Helwan material. Test large, robust; chambers numerous with their lower margins excavated and with overhanging lateral lobulations; sutures irregularly rugose; peripheral margin of the test subacute. Specimens resemble those recorded from the Red Sea (Said, Contr. Cushman Found. Foram. Res., **1**: 5, pl. 1, fig. 5, 1929.).

Textularia pseudorugosa Lacroix

Textularia pseudorugosa Lacroix, Bull. Inst. Oceanogr. 582: 11, fig. 3 (in text). 1931.

This is a Mediterranean species known from the deeper Recent waters of this Sea. It is a well-defined species with a rapidly expanding keeled test, distinct sutures, and numerous chambers three times as wide as high.

Textularia sagittula Defrance

Textularia sagittula Defrance, Dict. Sci. Nat. **32**: 177. 1824; **53**: 344. 1828; Atlas Conch.; pl. 13, fig. 5. 1824.

This is a deep-water Mediterranean species that is recorded in small numbers in the outcrop studied.

Family Miliolidae

Genus **Quinqueloculina** d'Orbigny, 1826

Quinqueloculina foliacea (Terquem)

Triloculina foliacea Terquem, Mém. Soc. Géol. France, ser. 3, **1**, pt. 3: 60, pl. 6, figs. 1a–c. 1878.

Specimens of this Lower Pleistocene species of the Mediterranean region are found in small numbers in the Helwan material. The test is somewhat foliated with the foliae extending in keel-like projections at the edge of the chambers. This is a distinct and well-defined species.

Family Lagenidae

Genus **Robulus** Montfort, 1808

Robulus cultratus (Montfort)

Robulina cultrata d'Orbigny, Ann. Sci. Nat. **7**: 287, no. 1. 1826; Modèles no. 82. 1826.

This cosmopolitan species is found in small numbers in the Egyptian material. According to Cushman and McCulloch (Allan Hancock Pacific Exped. **6** (6): 296, 1950) this species is recorded from deep waters at an average depth of 65 to 90 fathoms. Our specimens lack the keeled periphery of specimens of many authors although they resemble the forms recorded from the late Tertiary deposits of the Mediterranean region by the earlier workers.

Genus **Nodosaria** Lamarck, 1812

Nodosaria sulcata d'Orbigny

Nodosaria sulcata d'Orbigny, Ann. Sci. Nat. **7**: 253, no. 21. 1826. Cushman, Cushman Lab. Foram. Res. Special Publ. 13: 12, pl. 2, fig. 2; pl. 3, fig. 2. 1945.

A few specimens of this species, which is known from the Italian Pliocene and Recent Mediterranean, are recorded in Helwan. They are always 2-chambered and costate.

Family Nonionidae

Genus **Nonion** Montfort, 1808

Nonion ibericum Cushman

Nonion ibericum Cushman, U. S. Geol. Surv. Prof. Paper 191: 17, pl. 4, figs. 17, 18. 1939.

A few typical specimens of this species are found in Helwan. The small test, the rounded periphery, the umbilical plug, and the sigmoidal sutures characterize this species. This is a Pleistocene species recorded previously from Malaga, Spain.

Nonion pompiloides (Fichtel and Moll)

Nonion umbilicatula d'Orbigny, Ann. Sci. Nat. **7**: 293, pl. 15, figs. 10–12. 1826.

Nonion pompiloides Cushman, U. S. Geol. Surv. Prof. Paper 191: 19, pl. 5, figs. 9–12. 1939.

A few specimens of this species are recorded from Helwan. Specimens are smaller than is usual and are thinner. This is mainly a Mediterranean species known from the late Cenozoic and Recent waters of this region as well as from many other localities.

Genus **Elphidium** Montfort, 1808

Elphidium crispum Linné

Elphidium crispum Cushman, Contr. Cushman Lab. Foram. Res. **5**: 20, pl. 4, figs. 3, 4. 1929.

Several typical specimens of this Mediterranean species are recorded from the Helwan material.

Family POLYMORPHINIDAE

Genus **Pyrulina** d'Orbigny, 1830

Pyrulina fusiformis (Roemer)

Polymorphina fusiformis Roemer, Neues Jahrb. für Min., etc., 1838: 386, pl. 3, fig. 37.
Pyrulina fusiformis Cushman and Ozawa, Proc. U. S. Nat. Mus. **77** (art. 6): 54, pl. 13, figs. 3–8. 1930.

This deep-water species, recorded from modern seas and late Tertiary deposits of the Mediterranean region, is noted in small numbers in the Helwan material. Specimens differ slightly from those of the deep Atlantic by having more depressed sutures.

Family BULIMINIDAE

Genus **Bulimina** d'Orbigny, 1826

Bulimina acanthia Costa

Bulimina acanthia Costa, Atti. Accad. Pont. **8,** pt. 2: 335, pl. 13, figs. 35, 36. 1856.

A few specimens of this species occur in our material. The chambers are inflated particularly in the latter part of the test with slight overhanging but are not ornamented with any spines. This species is common in the Italian Pliocene.

Bulimina buchiana d'Orbigny

Bulimina buchiana d'Orbigny, Foram. Fossiles Bassin Vienne: 186, pl. 11, figs. 15–18. 1846.

This Miocene Mediterranean species is found in the Helwan material in abundance. Specimens are smaller than usual and the test is ornamented with extremely fine longitudinal costae. The chambers are inflated and there is no overhanging.

Bulimina costata d'Orbigny

Bulimina costata d'Orbigny, Ann. Sci. Nat. **7:** 269, no. 1, 1826.

This species occurs in abundance in the Egyptian material. Specimens are typical. This species seems to be one of the autochthonous forms of the Mediterranean region that has been recorded from since the Miocene to the Recent. It is also recorded off the coast of Ireland.

Bulimina elongata d'Orbigny

Bulimina elongata d'Orbigny, Ann. Sci. Nat. **7:** 269, no. 9. 1826.

This species is found in abundance in the Egyptian material. Specimens have an elongate slender test, inflated and angled chambers, and smooth polished wall. Our specimens resemble those recorded from the Mediterranean area. This species ranges from the Eocene to the Recent and seems to have its origin in the Mediterranean region.

Bulimina gibba Fornasini

Bulimina gibba Fornasini, Mem. Accad. Sci. Ist. Bologna, ser. 5, **9:** 378, pl. O, figs. 32–34. 1901.

This species was recorded in the top part of the section. Specimens are typical except that very faint costae appear on the otherwise smooth and polished test. The terminal basal spine is lacking, but there are short spines that ornament the base. The chambers are distinct, regularly triserial, slightly inflated and offset so as to give a slight twist to the test.

Bulimina inflata Seguenza

Bulimina inflata Seguenza, Atti Accad. Gioenia Sci. Nat., ser. 2, **18:** 25, pl. 1, fig. 10. 1862.

This Mediterranean and east Atlantic species occurs in the Egyptian material in small numbers. Test widest near top with the last whorl forming about one-third of the entire length. This species is characterized by having broad costae, a rapidly tapering test and chambers that do not overhang. This is one of the species that has probably invaded the Mediterranean in a cold period. It is common in the Pleistocene of Italy. Records of this species in older sediments need revision.

Bulimina pupoides d'Orbigny

Bulimina pupoides d'Orbigny, Foram. Fossiles Bassin Vienne: 185, pl. 11, figs. 11, 12. 1846.

A few specimens of this species are found in the top beds of the Helwan section. They approach in their structural detail those recorded from the Mediterranean region. Specimens lack, however, the lip and the tooth in the aperture. This species has a long record but is common in the late Cenozoic of the Mediterranean region.

Genus **Bolivina** d'Orbigny

Bolivina aenariensis (Costa)

Brizalina aenariensis Costa, Atti Accad. Pont. **8,** pt. 2: 297, pl. 15, figs. 1A, B. 1856.

This is a late Tertiary Mediterranean species that has been much confused. Specimens look very much similar to those recorded from the Pliocene of Coroncina, Italy, in having an elongate test without a spine at the base, sutures slightly limbate and strongly curved, and the characteristic costae on the surface extending from the base to the middle of the test.

Bolivina catanensis Seguenza

Bolivina catanensis Seguenza, Atti Accad. Gioenia Sci. Nat., ser. 2, **18:** 29, pl. 2, figs. 3, 3a, 3b. 1862.

This is a typical Mediterranean species that is recorded from the Pleistocene of Italy. Specimens are compressed and have an elongate test which is occasionally twisted in its initial end.

Bolivina cf. **B. compacta** Sidebottom

Bolivina robusta var. *compacta* Sidebottom, Mem. Proc. Manchester Lit. Phil. Soc. **49** (5): 15, pl. 3, fig. 7. 1905.

A few specimens that seem to belong to this species are found in Helwan. Specimens differ from typical in having a more roughened exterior, a rounded initial end, and a more elongate test. This is a Mediterranean species that has been recorded from many Recent seas at different depths.

Genus **Reussella** Galloway, 1933

Reussella spinulosa (Reuss)

Verneuilina spinulosa Reuss, Denkschr. Akad. Wiss. Wien. **1:** 374, pl. 47, fig. 12. 1850.
Verneuilina spinulosa Reuss, Denkschr. Akad. Wiss. Wien **1:** 374, pl. 47, fig. 12. 1850.

A few typical specimens of this cosmopolitan species are found in the Helwan material.

Genus **Uvigerina** d'Orbigny, 1826

Uvigerina costai Said, new name

Uvigerina striata Costa (non d'Orbigny), Atti Accad. Pont. **7** (fasc. 2): p. 266, pl. 15, fig. 3. 1856.—Cushman and Todd, Contr. Cushman Lab. Foram. Res. **17:** 71, pl. 17, fig. 4. 1941.

Specimens resembling Costa's figures for this species have been found in the Helwan material. Test moderate in size for the genus, elongate, circular in transverse section, base tapering; chambers equal, rather large, slightly inflated; sutures distinct; wall with fine longitudinal striae interrupted at the sutures, extending through the length of the test equally; aperture at the end of a short neck, very slightly lipped.

This species deserves a new name as *U. striata* has been used by d'Orbigny in 1826 for a Recent species.

Genus **Unicosiphonia** Cushman, 1935

Unicosiphonia cf. **U. crenulata** Cushman

Unicosiphonia crenulata Cushman, Contr. Cushman Lab. Foram. Res. **11:** 81, pl. 12, figs. 9, 10. 1935.

A few specimens of this species are found in Helwan section. Specimens are slightly different in having a more rounded initial end that does not show any traces of biseriality and in having more poorly developed crenulations. This is the first record of this species in the Mediterranean region.

Family Rotaliidae

Genus **Discorbis** Lamarck, 1804

Discorbis orbicularis (Terquem)

Discorbina orbicularis H. B. Brady, Rep. Voy. *Challenger*, Zoology, **9:** 647, pl. 88, figs. 4–8. 1884.

This is mainly a Mediterranean east Atlantic species of wide geographical distribution in Recent waters. It is also recorded from the late Tertiary deposits of the Mediterranean region, although it seems not to have invaded the Recent Mediterranean except in the Calabrian time.

Family Amphisteginidae

Genus **Asterigerina** d'Orbigny, 1839

Asterigerina rhodiensis Terquem

Asterigerina rhodiensis Terquem, Mém. Soc. Géol. France, ser. 3, **1,** pt. 3: 31, pl. 3, figs. 1–4. 1878.

Typical specimens of this species recorded from the lower Pleistocene of the Isle of Rhodes are recorded in abundance in the Helwan material.

Family Globigerinidae

Genus **Globigerina** d'Orbigny, 1826

Globigerina bulloides d'Orbigny

Globigerina bulloides d'Orbigny, Ann. Sci. Nat. **7:** 277, no. 1. 1826; Modèles nos. 17, 76. 1826.—Cushman, Contr. Cushman Lab. Foram. Res. **17:** p. 38, pl. 10, figs. 1–13. 1941.

Typical and well-preserved specimens of this species are recorded in large numbers at the top beds of the Helwan section. They agree in detail with d'Orbigny's original descriptions and models. The occurrence of this species in abundance indicates conditions where the effect of freshening of water was not felt.

Family Anomalinidae

Genus **Planulina** d'Orbigny, 1826

Planulina sp.

Test much compressed, partly evolute, earlier chambers visible from both sides; chambers

numerous; sutures distinct, flush with the surface, curved slightly toward the periphery; ventral side umbilicate; wall perforate, smooth; aperture at the base of the last chamber at the median line. The compressed large test and the wide circular umbilicus of the ventral side distinguish this species found in very small numbers in the top bed of the Helwan section.

Genus **Cibicides** Montfort, 1808

Cibicides gibbosa (Terquem)

Anomalina gibbosa Terquem, Mém. Soc. Géol. France, ser. 3, **1**, pt. 3: 24, pl. 2, fig. 7. 1878.
Cibicides gibbosa Said, Cushman Lab. Foram. Res. Special Publ. 26: 43, pl. 4, fig. 19. 1949.

Typical specimens of this species hitherto recorded from the Lower Pleistocene of the Isle of Rhodes and the Recent Red Sea are found in large numbers in the Helwan material. This species is biconvex and is coarsely perforate. It possesses the apertural characteristics of the genus *Cibicidoides* Brotzen, 1936. The author prefers to place this species in the genus *Cibicides* until the validity of the genus *Cibicidoides* is cleared (see Hofker, 1951, *Siboga* Exped. III).

Cibicides lobatulus (Walker and Jacob)

Truncatulina lobatula H. B. Brady, Rep. Voy. *Challenger*, Zoology, **9**: 660, pl. 92, fig. 10; pl. 93, figs. 1, 4, 5; pl. 95, figs. 4, 5. 1884.

Typical specimens of this cosmopolitan species are found in the Helwan material. According to Cushman this is a "very common species in cool waters." There are records, however, of this species in deeper tropical waters and in tropical shallow seas, but such records probably need revision.

Cibicides refulgens Montfort

Cibicides refulgens Cushman, U. S. Nat. Mus., Bull. 104, pt. 8: 116 pl. 21, figs. 2a–c. 1931.

This is a cosmopolitan species that is particularly abundant in cool waters of the modern seas, according to H. B. Brady.

Cibicides rhodiensis (Terquem)

Truncatulina rhodiensis Terquem, Mém. Soc. Géol. France, ser. 3, **1**, pt. 3: 21, pl. 1, fig. 26. 1878.
Cibicides rhodiensis Said, Cushman Lab. Foram. Res. Special Publ. 26: p. 42, pl. 4, fig. 16. 1949.

This species recorded from the Lower Pleistocene of the Isle of Rhodes and the Recent Red Sea is found in abundance in Helwan. The distribution of this species can be explained only if we assume a temporary connection to have existed between the Mediterranean and the Red Sea sometime in the Pleistocene. Specimens are typical and abundant.

REFERENCES

BALL, J. *Contributions to the geography of Egypt: Survey of Egypt*. 1939.

BLANCKENHORN, M. *Neues zur Geologie und Paleontologie Aegyptens: IV. Das Pliozan*. Zeitschr. deutschen geol. Ges. **53**: 307–502. 1903.

———. *Handbuch der regionalen Geologie, Aegypten*. Heidelberg, 1921.

COLOM, G. *Una contribución al conocimiento de los foraminíferos de la Bahia de Palma de Mallorca*. Notas y Res. Inst. Español Oceanografía, ser. 2, no. 108. 1942.

COX, L. R. *Notes on the post-Miocene Ostereidae etc*. Proc. Malac. Soc. London **48**, pts. 4 and 5: 165–209. 1929.

HUME, W. F., and LITTLE, O. H. *Raised beaches and terraces of Egypt*. C. R. Union Geogr. Intern., Paris (session 14, 1926): 9–15. 1928.

MOVIUS, H. M. *Villafranchian stratigraphy in southern and southwestern Europe*. Journ. Geol. **57**: 380–412. 1949.

NAPOLI-ALLIATA, E. DI. *Contributo all conoscenza della stratigrafia del Pliocene e del Calabriano nella regione di Rovigo*. Riv. Ital. Paleontologia **52**: 19–36. 1946.

PICARD, L. *The structure and evolution of Palestine*. Bull. Geol. Dept. Hebrew University **4**, Nos. 2–4. 1943.

SAID, R., and KAMEL, T. *Recent littoral Foraminifera from the Egyptian Mediterranean coast between Saloum and Bardia*. (In press.)

SAID, R., and YALLOUZE. *Miocene fauna from Gebel Oweibid, Egypt*. Bull. Inst. Egypte. (In press.)

SANDFORD, K. S., and ARKELL, W. J. *Paleolithic man and the Nile Valley in Lower Egypt*. Oriental Inst. Publ. **46**. 1939.